EQUIPMENT

Locomotive Hauled vs. Diesel Multiple Units

Ohio Rail Development Commission

November 19, 2009

Presentation Outline

- Typical Characteristics
  - Locomotive-hauled equipment
  - DMU
- Performance
  - Acceleration
  - Fuel Efficiency
  - Emissions
- 3C Capacity Needs
- US Rail Car
  - Field Review of Bi-level Colorado Rail Car DMU
- Summary of Findings

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Amtrak Proposed 3C "Quick Start" Consist

Locomotive-hauled push-pull Equipment

- 1 Locomotive
  - $5 Million
- 5 Single-level Coaches
  - $4 Million each
  - 60 to 70 seats each
  - 85 Feet Long
- 1 Bistro/Café Car
  - $5 Million
- 1 Non-powered Control Unit
  - $2 Million
- Cost per Consist: $32 M

Locomotive-hauled Typical Characteristics

- Diesel engine drives electric generator that supplies approximately 3500 HP to electric motors on the locomotive's drive-wheels
- A separate generator provides electric power to heat, cool and light the passenger coaches.
- Weights 135 tons and meets FRA crash-worthiness standards (69 feet long)
- Maximum train consist hauled by one locomotive is typically 8 or 9 coaches.

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Diesel Multiple Units

- Budd 1950's Rail Diesel Car (RDC)

- Trinity River Express Rebuilt Budd RDC Dallas, Texas

- Colorado Rail Car Single-level DMU

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Diesel Multiple Units Typical Characteristics

- On-board motive power.
- Power cars have two 600 HP diesel engines.
- Maintenance requirements are similar to a bus.
- Push-pull service with a cab at each end.
  - A single-level DMU car weights about 88 tons.
  - A bi-level DMU car weight about 100 tons.
- Only one manufacturer offers DMU's that meet FRA crash worthiness standards
- DMU equipment is most appropriate for low-density corridors and commuter rail markets.

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Rail Diesel Car (RDC)
Amtrak Specification - 2003

- ***Service Objectives***:
- "To provide low-cost train service on new or existing regional routes where passenger volumes do not justify loco-hauled trains."
- "To provide quick turns at end-points and allow mid-route consist size changes on Y-shaped routes."
- "To be used primarily in regional service, but capable of operating anywhere in the Amtrak System, including commuter lines."
- "For trains shorter than 4 to 6 cars, the RDC is cheaper to operate."

Diesel Multiple Units
Potential Advantages

- Compared to locomotives DMU's have the potential to:
  - **Reduce train run-time**
  - **Reduce fuel usage**
  - **Reduce emissions**
  - **Reduce maintenance costs**

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Acceleration

- DMU's can reduce running times due to faster acceleration than locomotive-hauled trains.
- DMU's can accelerate in the range of 0.8 to 2.4 mph per second, compared to 0.5 mph per second for conventional locomotives.
- Automatic doors and wider doors at lower floor heights can speed the boarding process and reduce station dwell times.

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Acceleration

	DMU			Loco-Hauled Train		
Speed mph	Time (secs)	Distance (feet)	Accel (mphps)	Time (secs)	Distance (feet)	Accel (mphps)
0	0	0	0	0	0	0
30	32	798	0.61	65	1,486	0.41
45	65	2,614	0.37	108	3,873	0.32
60	123	7,129	0.21	166	8,388	0.23

- A mix of 50% DMU's and 50% trailer cars could accelerate to 30 mph in 32 seconds, versus 65 seconds for a locomotive.
- Acceleration to 60 mph would take 123 seconds, versus 166 seconds for existing service.

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Fuel Efficiency

- Locomotive fuel consumption is approximately 2.8 gallons per train mile.
- DMU fuel consumption is directly related to the number of power cars operated.
- DMU fuel consumption ranges from 0.6 gallons per mile for a single DMU to 2.2 gallons per mile for a five car train with two power cars and three trailer cars

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Fuel Efficiency

- Fuel consumption is lower for loco-hauled trains when trains are 6 or more cars.
- Fuel consumption is lower for DMU operations when trains are 5 cars or less.

Emissions

- Emissions characteristics are related to engine type and total horsepower
- Emissions for loco-hauled service is not greatly affected by train length
- Emissions for DMU service is directly related to train length.
- At all train lengths, DMU's have lower emission levels than loco-hauled equipment.

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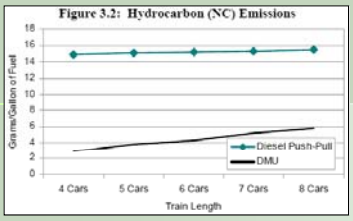
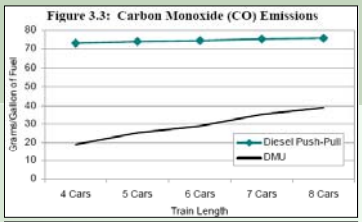
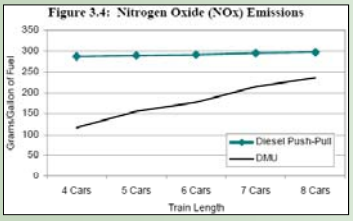
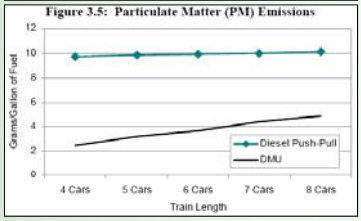
Emissions









- Emission rates for DMU vehicles are 42% to 73% lower than for diesel locomotive service.
- As with fuel consumption, emission rates for diesel locomotives is impacted only slightly by train length, while emission rates for DMU service increases or decreases in proportion to train length.

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Locomotive-hauled Bi-Level Coaches

Long-distance and Corridor Trains

Amtrak Superliner

California Car

- Low-floor access
- Second-level car-to-car passageway

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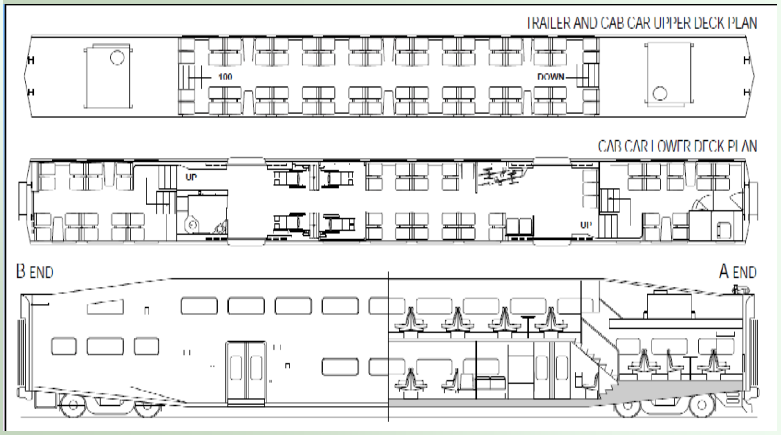
Loco-hauled Bi-level Coaches

Bombardier Commuter Rail Car



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Loco-hauled Multi-level Coaches

Kawasaki

Commuter Rail Cars

Massachusetts Bay Trans Auth

Long Island RR

Maryland MTA

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Midwest Regional Rail Initiative Request for Information

- RFI specified 300 seats and 110 mph top speed
- Planning Assumption: Delivery in 48 months after selection of vendor
- Nine Vendors Responded to RFI:
  - Alstom; Ansaldo Breda; Bombardier; Kawasaki; Siemens Mobility; Talgo; US Rail Car, LLC., General Electric; Motive Power, Inc.
- Some responses were "off the shelf," some was not
- Vendors will not discuss timeframe for delivery without detailed technical or performance specifications
- MWRRI Equipment Report due out in December

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3C Train Consist Capacity Requirements

- Cleveland to Columbus has the highest ridership.
- Annual 2014 Segment Volume: 507,000 to 612,000
- Based on a 350 Seat Train the load factor is 66%-79%
- At three frequencies per day the 3C Corridor Market appears strong and pushes the limit on DMU Capacity

Line Segment	Segment Forecast Range	Passengers per train	350 Seat Train Load Factor
Cleveland – SW Cleveland	203 ,000 - 234,000	93 – 107	26% - 31%
SW Cleveland – Columbus	507,000 - 612,000	231 – 279	66% - 79%
Columbus – Springfield	507,000 - 493,000	231 – 225	66% - 64%
Springfield – Dayton	371,000 - 461,000	169 – 210	48% - 60%
Dayton – Sharonville	199,000 - 314,000	91 – 143	26% - 41%
Sharonville - Cincinnati	42,000 - 69,000	19 - 31	5% - 8%

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DMU Passenger Capacity

- Colorado Rail Car – 6 car single-level train
  - Seating Capacity: 340
- Colorado Rail Car – 3 car bi-level train
  - Seating Capacity: 370

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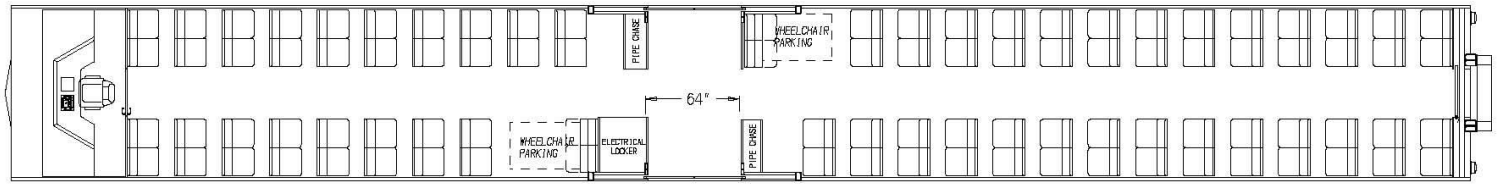
Single Level DMU

Seats	94
Length (over coupler pulling faces)	85' or 89'
Width (over side sheets)	10'
Total height (above top of rail)	14' 11"
Floor height (above top of rail)	51"
Engine	Two Detroit Diesel Series 60 Each rated at 600 hp
Transmission	Two Voith T212 BRE with KB190 retarder
Final Drive	Two Voith KE553

94 Seat Single Level DMU



PLAN VIEW

94 SEATS (INCLUDING 4 FLIP SEATS OR 2 WHEELCHAIR PARKING SPOTS)

Single Level Coach

Seats	102
Length (over coupler pulling faces)	85' or 89'
Width (over side sheets)	10'
Total height (above top of rail)	14'11"
Floor height (above top of rail)	25" or 51"

102 Seat Single Level Coach

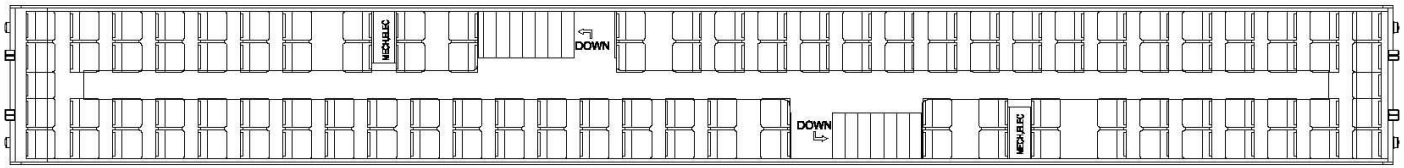
PLAN VIEW

102 SEATS (INCLUDING 4 FLIP SEATS OR 2 WHEELCHAIR PARKING SPOTS)

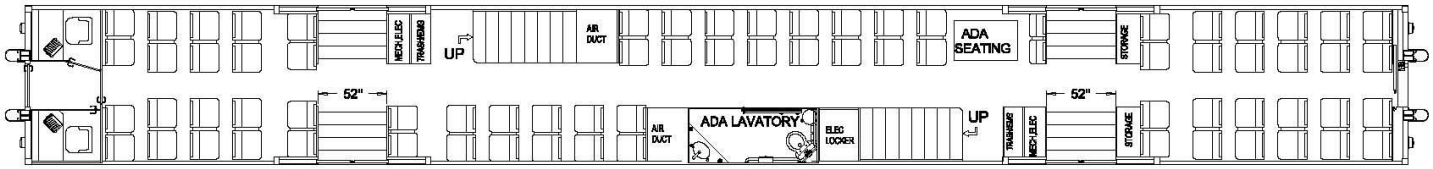
New Double Deck DMU

Seats	188
Length (over coupler pulling faces)	89'
Width (over side sheets)	10'
Total height (above top of rail)	19' -9 1/2"
Floor height (above top of rail)	51"
Engine	Two Detroit Diesel Series 60 Each rated at 600 hp
Transmission	Two Voith T212 BRE with KB190 retarder
Final Drive	Two Voith KE553

188 Seat Double Deck DMU



PLAN VIEW
UPPER LEVEL - 114 SEATS @ 32" PITCH

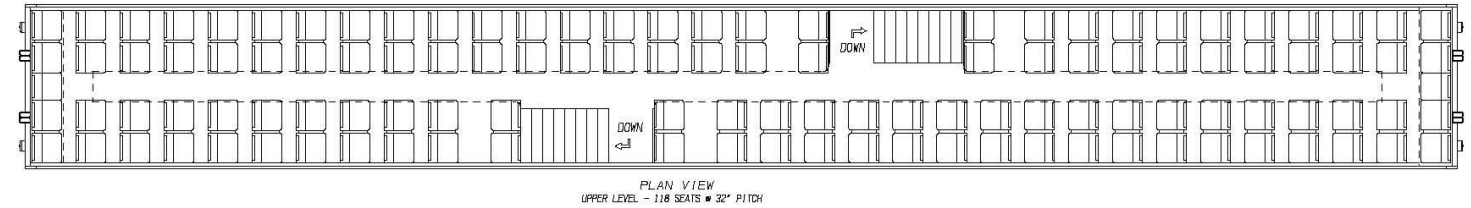


PLAN VIEW
LOWER LEVEL - 74 SEATS @ 32" PITCH

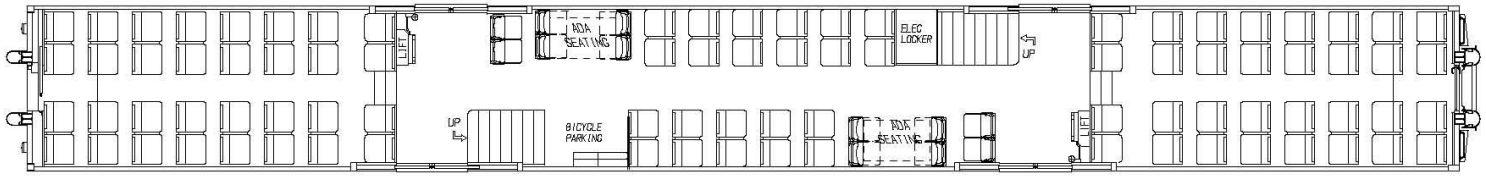
218 Seat Low Floor Double Deck Coach

Seats	218
Length (over coupler pulling faces)	89'
Width (over side sheets)	10'
Total height (above top of rail)	19' -9 1/2"
Low floor height (above top of rail)	25"
Control cabs	Available for push-pull operation

218 Seat Double Deck Coach



PLAN VIEW
UPPER LEVEL - 118 SEATS @ 32" PITCH



PLAN VIEW
LOWER LEVEL - 100 SEATS @ 32" PITCH

Colorado Rail Car

South Florida RTA
Bi-level DMU – Three Car Train Consist

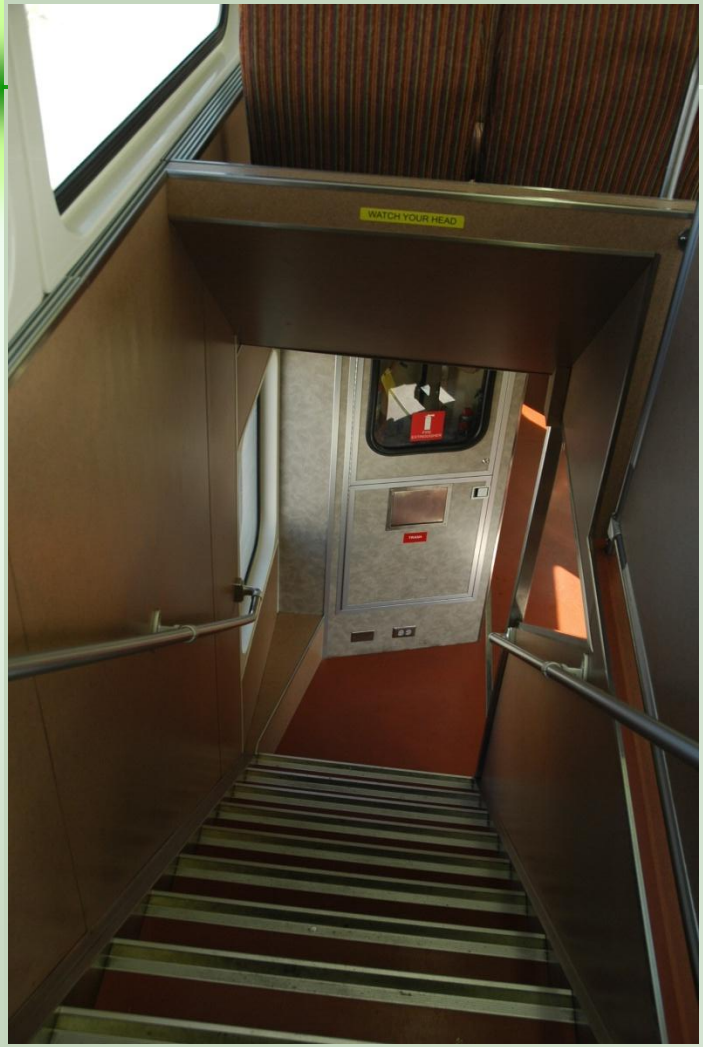
Trailer Car in Foreground (lower floor entry)
Power Car in Background (high-level entry)

Power Car
High-level Entry
Automatic doors

Power Car Interior
Lower Level

Trailer Car
Low-level ADA Entry and Interior

Power Car Stairway



Trailer Car Stairway

Trailer Car Interior Lower Level

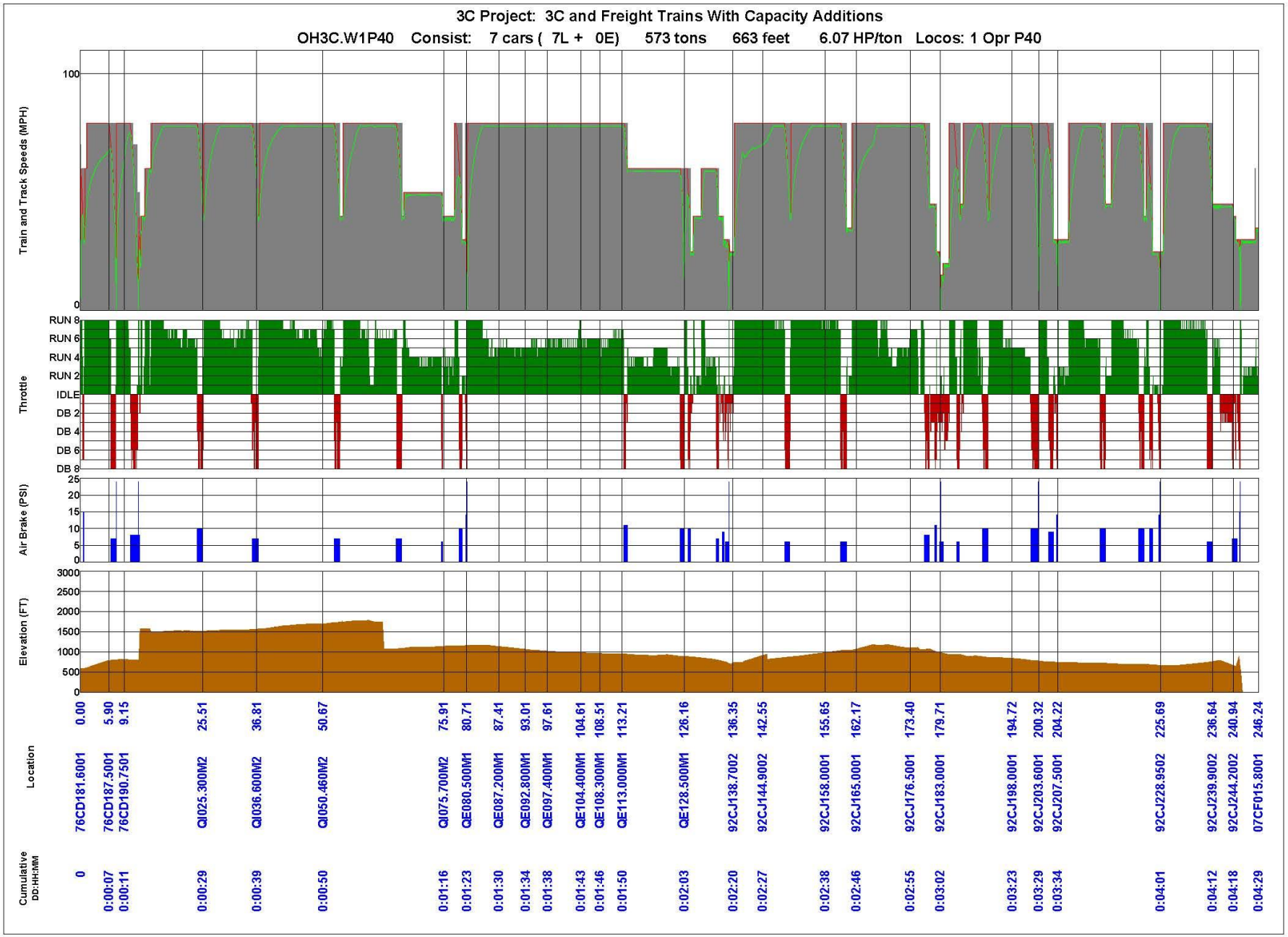
Power Car Interior
Upper Level

Power Car Interior
Upper Level

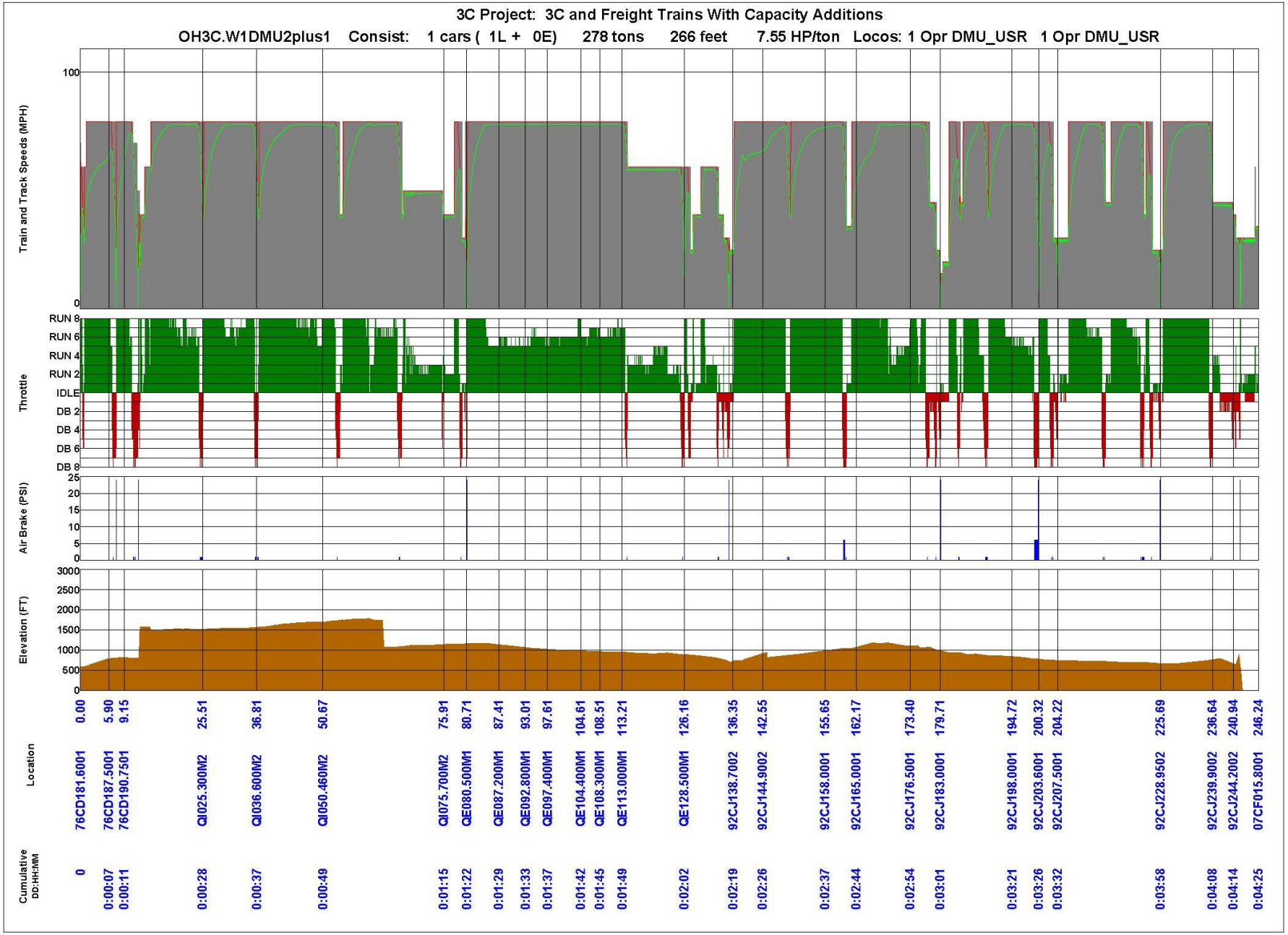
Trailer Car Interior
Upper Level

Trailer Car Interior
Upper Level

Car body structure meets FRA buff-strength requirements
Note: Car-to-car passageway on lower-level



Case: ORDC 3C08Cap TPC RTC run: 17 November 2009 10:26:28 User: Judy Roberts of Woodside Consulting Group



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TBM

3 C "Quick Start" Service - DMUs vs Loco hauled types

Rev. 11/18/09 2pm

DMU Single Level

# Pass	# Cars	DMU Car	# of Eng.	Horse Power Total	Per Pass.	Per Ton
			2	1050	11	7
	1	Power				
100	1	Bistro		Cost per pass. $88 ,000		
	2	Power	4	2100	10	6
	1	Bistro				
220	1	Trailer		Cost per pass. $79 ,000		
	3	Power	6	3150	9.3	5.7
	1	Bistro				
340	2	Trailer		Cost per pass. $76 ,000		
	4	Power	8	4200	9.1	6.5
	1	Bistro				
460	3	Trailer		Cost per pass. $75 ,000		
	5	Power	10	5250	10	6
	1	Bistro				
520	3	Trailer		Cost per pass. $75 ,000		

Loco. Hauled Single Level

# Pass	# Cars	Car Type	# of Eng.	Horse Power Total	Per Pass.	Per Ton
	1	Loco.	1	3480	35	11
	1	Bistro				
100	1	Coach		Cost per pass. $160 ,000		
	1	Loco.	1	3480	16	8
	1	Bistro				
220	3	Coach		Cost per pass. $109 ,000		
	1	Loco.	1	3480	10.2	6.0
	1	Bistro				
340	5	Coach		Cost per pass. $94 ,000		
	1	Loco.	1	3480	7.6	5.9
	1	Bistro				
460	7	Coach		Cost per pass. $87 ,000		
	1	Loco.	1	3480	7	5
	1	Bistro				
520	8	Coach		Cost per pass. $85 ,000		

DMU Bi-Level

# Pass	# Cars	DMU Car	# of Eng	Horse Power Total	Per Pass.	Per Ton
			2	1050	8	11
	1	Power				
130				Cost per pass. $65 ,000		
			2	1050	4	6
	1	Power				
240	1	Bistro		Cost per pass. $69 ,000		
			4	2100	5.7	7.5
	2	Power				
370	1	Bistro		Cost per pass. $68 ,000		
	3	Power	6	3150	6.3	8.4
	1	Bistro				
500	0	Trailer		Cost per pass. $67 ,000		
	3	Power	6	3150	5	7
	1	Bistro				
630	1	Trailer		Cost per pass. $66 ,000		

Locomotive Hauled Multi-level

# Pass	# Cars	Car Type	# of Eng	Horse Power Total	Per Pass.	Per Ton
			1	3480	46	17
	1	Loco.				
75	1	Bistro		Cost per pass. $144 ,000		
	1	Loco.	1	3480	19	12
	1	Bistro				
180	1	Coach		Cost per pass. $91 ,000		
	1	Loco.	1	3480	8.9	8.0
	1	Bistro				
390	3	Coach		Cost per pass. $70 ,000		
	1	Loco.	1	3480	7.0	6.8
	1	Bistro				
495	4	Coach		Cost per pass. $66 ,000		
	1	Loco.	1	3480	6	6
	1	Bistro				
600	5	Coach		Cost per pass. $64 ,000		

Locomotive hauled units - Cost:			Tons	Pass.
Single Level Pass.Car =	$4.0	million.	65	60
Single Level Bistro Car =	$5.0	million.	65	40
Single Level Loco Cab. Ca	$2.0	million.	55	
Multi Level Pass.Car =	$5.5	million.	75	105
Multi Level Bistro.Car =	$5.8	million.	75	75

DMU units - Cost:			Tons	Pass.
DMU Single Level Power Car	$4.5	million	88	60
DMU Single Level Trailer Car	$4.0	million	71	60
DMU Single Level Bistro Car :	$4.3	million	71	40
DMU Bi-level Power Car =	$8.5	million	96	130
DMU Bi-level Trailer Car =	$8.0	million	88	130
DMU Bi-level Bistro Car =	$8.0	million	88	110

Locomotives - Cost per unit:			Tons
P40 Locomotive =	$5.0	million.	135
HP with HEP = 3650			
Effective HP = 3480			

Comparison of Equipment Preliminary Findings

	Single-Level		Bi-Level	
	Loco-hauled	DMU	Loco-hauled	DMU
Units/Consist	8	6	5	3
Seats/Consist	340	340	390	370
Average Seats/Car	57	57	98	123
HP/Ton Higher is better	6.0	5.7	8.0	7.5
HP/Pass Seat Lower is better	10.2	9.3	8.9	5.7
Fuel Use on 3C Corridor One-way trip 260 miles (gal)	700	700	700	500
Fuel Savings/Yr @$2.25 per gallon	-	-	-	$1,000,000
Capital Cost/Consist	$32 Million	$25.8 Million	$27.4 Million	$25 Million
Capital Cost of Fleet	$160 Million	$129 Million	$137 Million	$125 Million
Capital Cost/Pass Seat	$94,000	$76,000	$70,000	$68,000
Length of Consist (feet)	660	534	405	267
Delivery Time (months)	42-48 mo	30 mo	36-48 mo	30 mo
Height of Cars	14	14.7	16.2	18

Next Steps

- Review 3C vertical clearances
- Initiate discussions with manufacturers
- Explore plan and design modifications
  - Evaluate bistro/café locations
  - Explore aerodynamic design possibilities
  - Assess engineering concerns related to relocation of air conditioning/radiators to first level to reduce car height
- Investigate obtaining the services of a nationally recognized expert on passenger rail equipment to assist ORDC/ODOT with the procurement effort